

Underground Mining

1870's – 1940's

The first of the “Mining for Modelers” clinic series



“Mining for Modelers” Clinics

- Mining 101: Underground Mining
 - Gold, copper, iron, and silver-lead-zinc, 1870’s – 1940’s
- Mining 102: Transportation and Milling
- Mining 103: Smelting of Ores



If it cannot be grown, it must be mined.

- **Mining** is the process whereby earth materials containing *economic values* of minerals, metals, or other substances needed by civilization are removed from the crust of the earth.
- The first miners were those people who *repeatedly* went to the same location to extract something of value from the earth:
 - Clay for pots
 - Flint for arrowheads, spear points, hide scrapers
 - Pigments for decorations
- Mining is probably the older of the oldest professions!



Types of Mining

- Placer Mining
 - Extraction of gold and other minerals from stream deposits
 - Early eastern US deposits, 1790's – 1840's
 - 49er's in California
 - Rocky Mountain west, 1850's – 1880's
 - Yukon and Alaska 1890's – 1900's
 - Essentially “low technology”
- Lode Mining
 - Extraction of minerals from veins (lodes) or “reef” deposits
 - Lodes/veins, and reef's are source for placer deposits
 - Follow placer deposit upstream, when placer disappears, look at hills/mountains to locate the vein



“Historical” vs. “Modern” mining

- “Historical” mining characterized by:
 - Small operations
 - Low technology:
 - lack of mechanization
 - Lack of electricity
- “Modern mining characterized by:
 - Deeper, lower grade deposits cost more to develop
 - Small miners lacked capital
 - Formation of investment “syndicates”
 - Guggenheim, Vanderbilt, Hearst, others
 - “Consolidation” of mining districts and claim groups



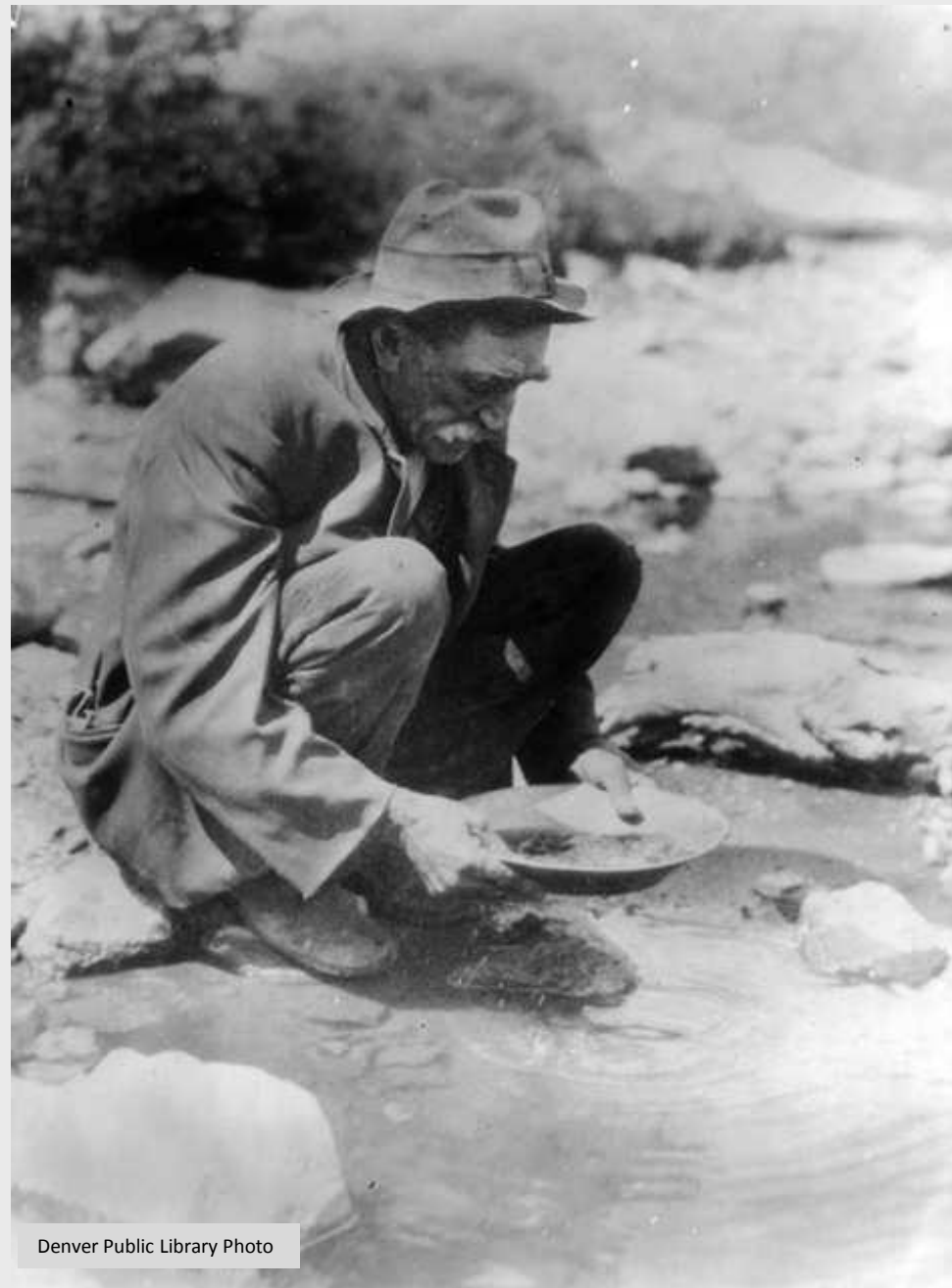
“Historical” vs. “Modern” mining

- “Modern mining characterized by:
 - 1872 Mining Law
 - Right to ownership on discovery
 - Mechanization
 - First steam drills, Simon Ingersoll and first compressed air drill, 1870’s
 - Legend of John Henry
 - Mining Universities became prominent
 - ‘Mining Engineer’ was (and still is) a *highly* respected career
 - “Cyanide process” more efficient than amalgamation for gold production. 1890’s
 - Widespread electrification, 1880’s and 1890’s



Placer Mining

- Non-mechanized
 - Pre-history to present
 - “49er’s” were all placer miners
 - Diminishes in use after mechanization in late 1880’s
- Mechanized
 - 1880’s to present
 - History Channel’s “Gold Rush” and “Bearing Sea Gold” TV series



Denver Public Library Photo

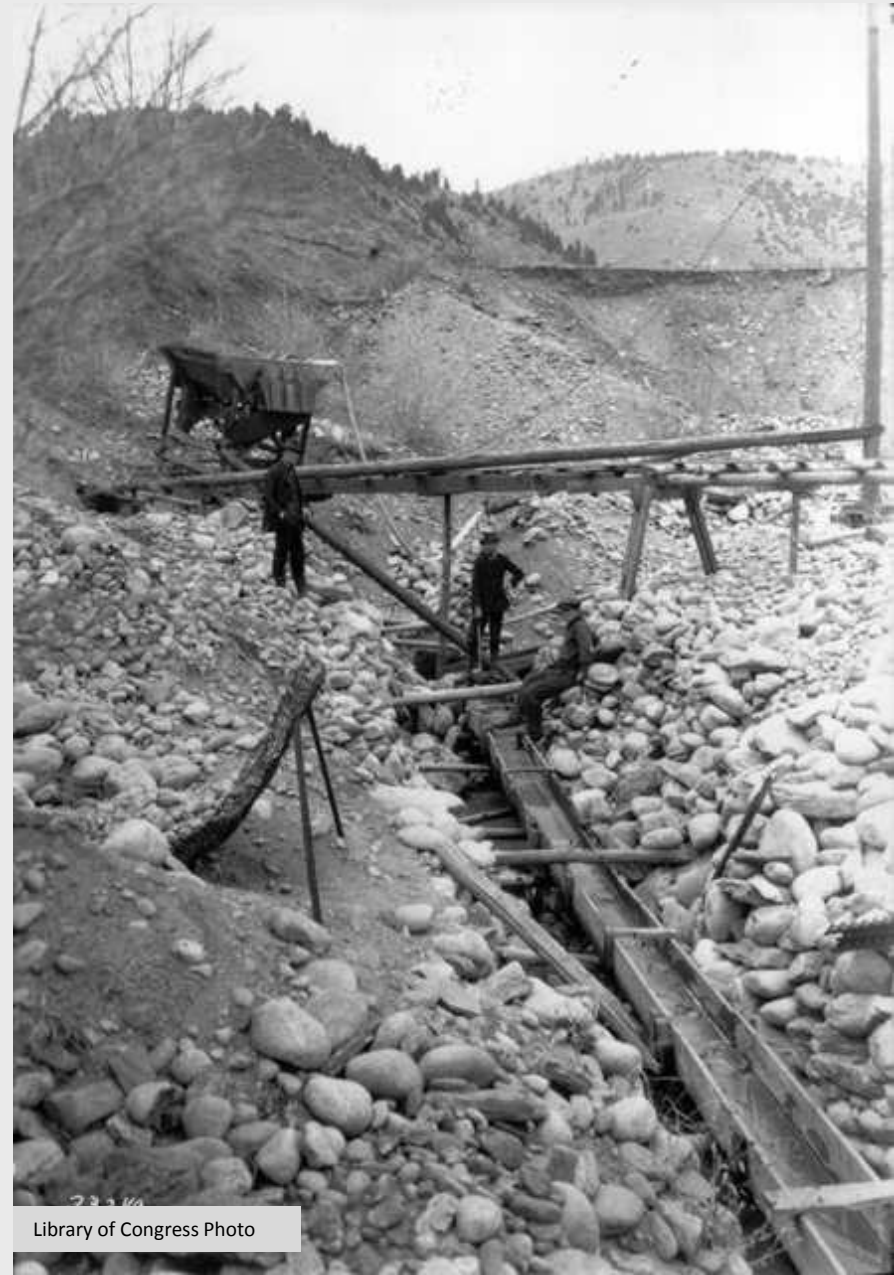
Placer Mining, non mechanized

- Hydraulic mining, Hahn's Peak, Colorado, 1880's
 - Extensive network of 'flumes' brings creek water to supply "monitors"
 - Monitors direct water against hillsides, wash rock, gravel down
 - Artificial creeks carried gold nuggets and dust into sluice boxes
 - Large capacity sluice boxes needed, daily to weekly 'cleanup'
 - Logistics: lumber, timber, piping, hoses, tools, food, fuel, etc. Wagons, no RR



Placer Mining, non mechanized

- Grizzly and sluice ('long tom'), 1930's
- Denver WPA class, 1930's bucket, shovel, rocker and pans
- Very low throughput



Placer Mining, Mechanized

- Colorado, 1940's
 - Shovel feeds mobile placer plant
 - Small draglines also used

Placer Mining, Mechanized

- Alaska Gold Mining Co. Dredge, 1940's
 - Floating plant, digs gravel from stream bottom
 - 50+ foot depth capability



Placer mining & stamp mill “clean-up”

- Mercury absorbs gold
 - Forms lumps of gold-mercury ‘amalgam’
- Mercury distilled out of amalgam by heat in retort
 - Fumes are highly toxic
 - Mercury is recovered
- Lump of gold remains behind
 - Gold now sellable, purity varies, needs refining for further use



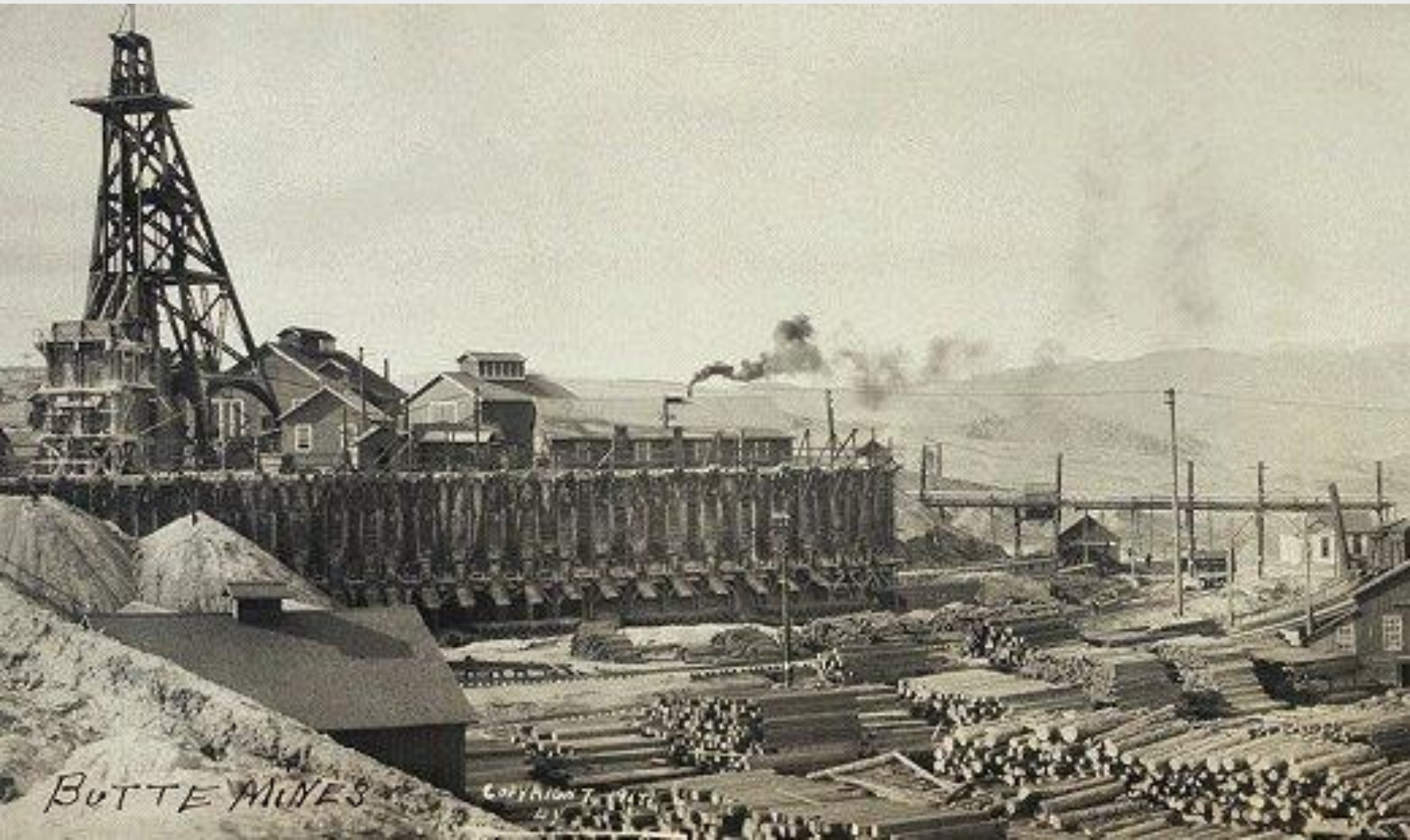
Lode Mining

- Mineralization occurs in a discrete 'vein', 'lode', or 'reef'



Lode Mining

- Can be very complex



Lode Mining

- Or relatively simple



Steps in the overall mining process

- Exploration for a mineral deposit
 - Find the desired mineral (in a large quantity)
- Evaluation of the deposit economics
 - Collect and assay 100's to 1,000's of samples
 - Create visual “model” of deposit
 - Define “waste”, “low grade”, “high grade”
 - Establish “ore body geometry”
 - Determine “mining plan” to exploit deposit
- Development of the deposit
 - Surface facilities
 - Establish initial access into ore body, haul roads (op), portals, drifts (ug)
 - Initial production sites
 - Stopes, draw points, ore passes, ventilation (ug); benches (op)



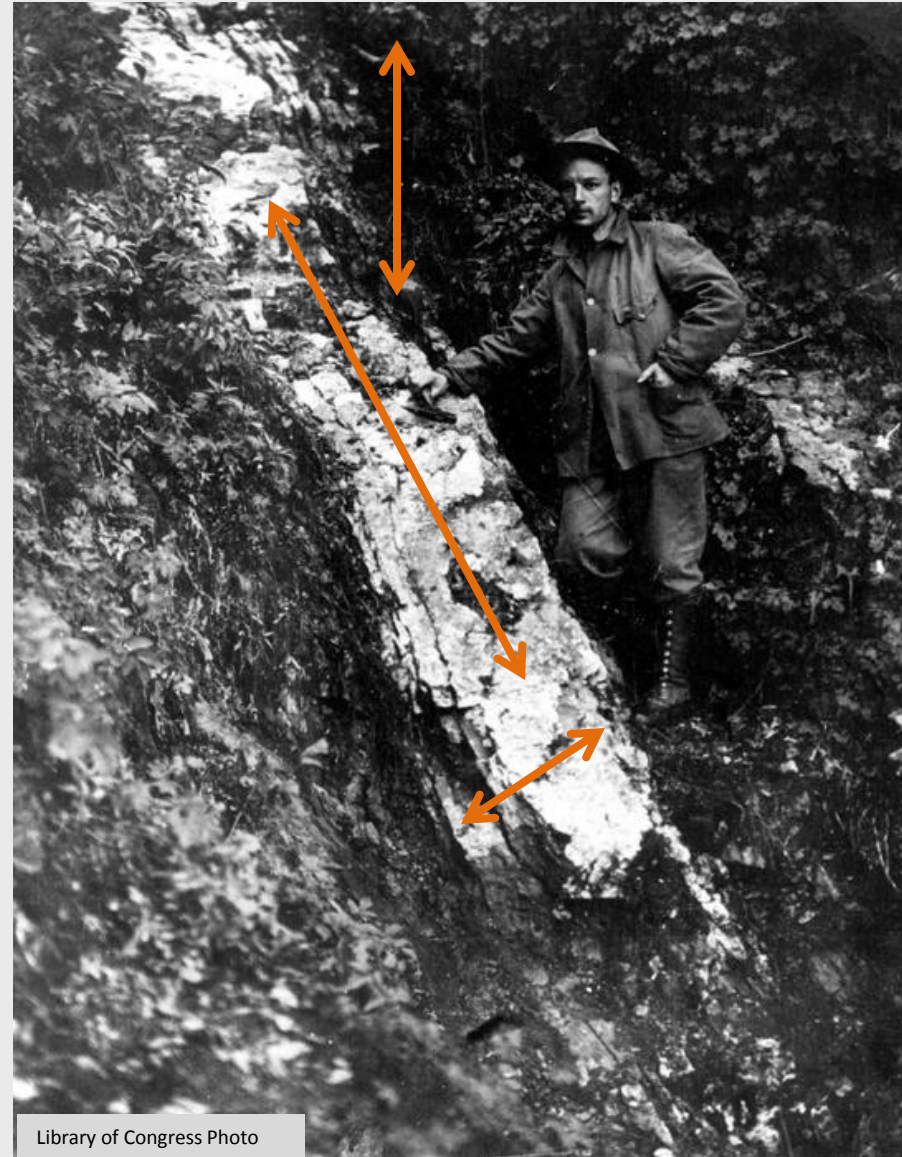
Steps in the overall mining process

- Production of 'ore'
 - Actual mining, processing and sale of economic values
- Beneficiation (milling & concentrating)
 - Liberate, separate, and concentrate the economic values from the uneconomic values
- Smelting
 - Production of 'raw' metal to be further refined
 - Copper "matte"; gold, silver "dore"; lead, zinc ingots, etc.
 - Smelting gives 95% - 99% pure metals
- Refining
 - Purification of the economic value into the substance needed by society
 - Copper, lead, zinc, typically 99.9% pure
 - Gold, silver, platinum, palladium typically 99.99% pure
 - Limestone to cement, titanium oxide to paint pigment, etc.



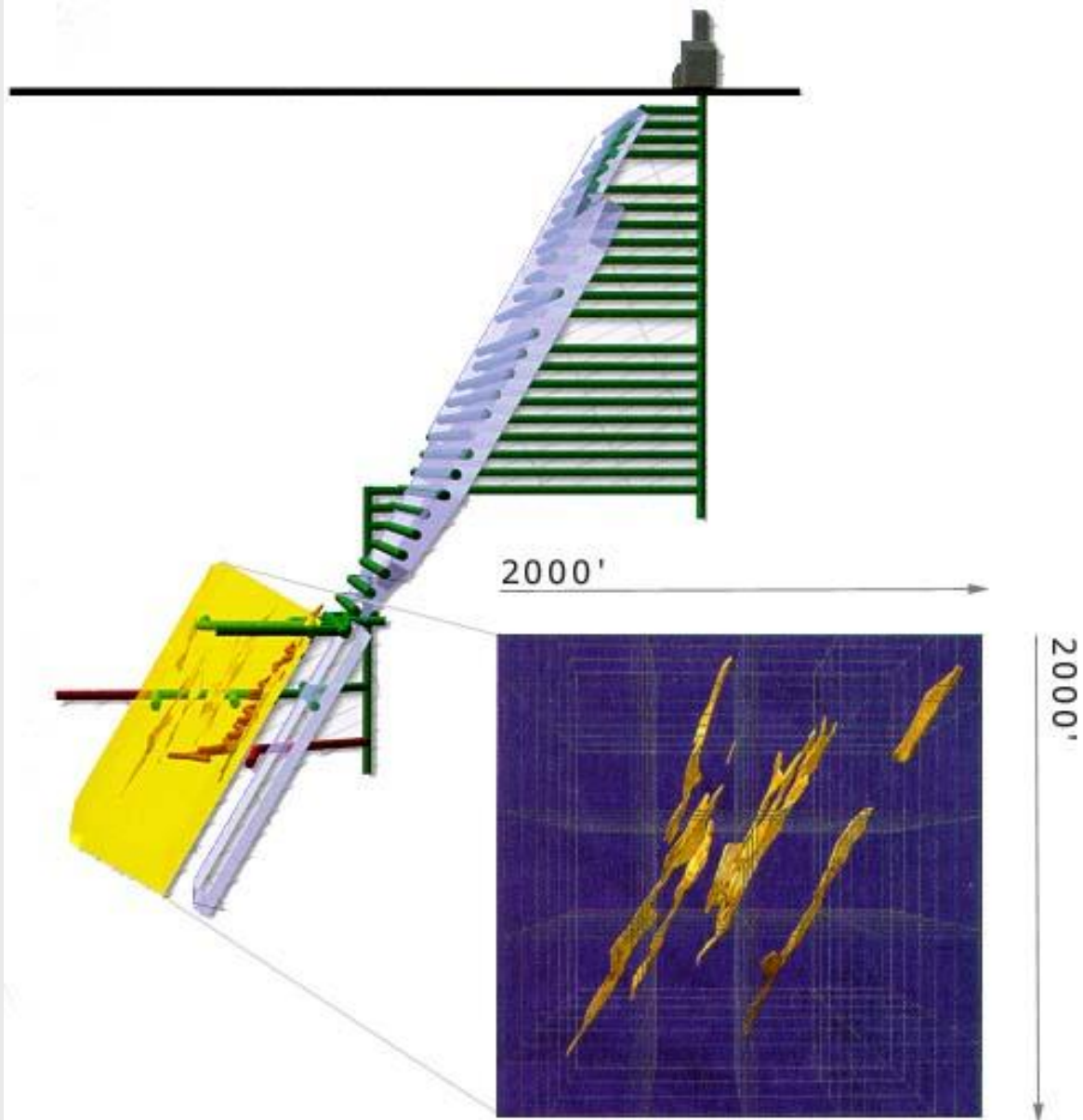
Orebody Modeling - Historical

- Vein is:
 - 1500 ft. long
 - 300 ft. tall
 - 2 feet thick
- Now . . .
 - $1,500 \text{ ft.} \times 300 \text{ ft.} \times 2 \text{ ft.} = 900,000 \text{ cubic feet} \times 165 \text{ \#/cuft} \div 2000 \text{ \#/t} = 74,250 \text{ tons}$
 - $74,250 \text{ tons} \times 1.5 \text{ oz/t} = 111,375 \text{ oz gold} \times \$20/\text{oz} = \$2,227,500$
- Whoopee!!
- We're RICH!!
- Let's get to diggin'!



Canadian Gold Deposit Model

- 3-D computer modeling
 - Shows entire mine
 - Requires 1,000's data points
 - Requires 10's of hours to process
- “Contest” mine
 - Mine about to close
 - All data available on internet
 - Available to public
 - Winning mine plan awarded \$1,000,000 on confirmation of viability



3 Dimensional Rendering :
Side view showing the relative position
of the numerous gold-bearing structures
making up the HGZ.

Folklore?

- Yosemite Sam and his 'desert canary' did exist!
 - Prospectors with mules are gone
 - Modern prospector is a college grad on a Polaris 4-wheeler



Denver Public Library Photo



What is typical?

- For model RR's:
 - Small UG gold/silver mine/mill operation
 - Both mines and mills were small capacity, 50 – 200 tpd output
 - 1 – 5 rail cars/day shipping rate to central mill if mine is “stand alone”
 - Could use aerial tramway to ship ore to mill or ore to rail ‘loadout’
 - 25 – 100 employees typical
 - Gold/silver mill processed ore into “dore”
 - Dore shipped to refinery
 - Site might be served by rail
 - Rail access typical in late 1800's, not much by 1930's
 - Mule/wagon haulage common 1860's – 1880's
 - Medium size mill operation, 200 – 500 tpd input
 - Ore railed to mill, or aerial tram from distant mines
 - Produces:
 - Gold, silver dore
 - Lead, zinc, copper concentrate for shipment to smelter
 - How ambitious? Selectively compress!



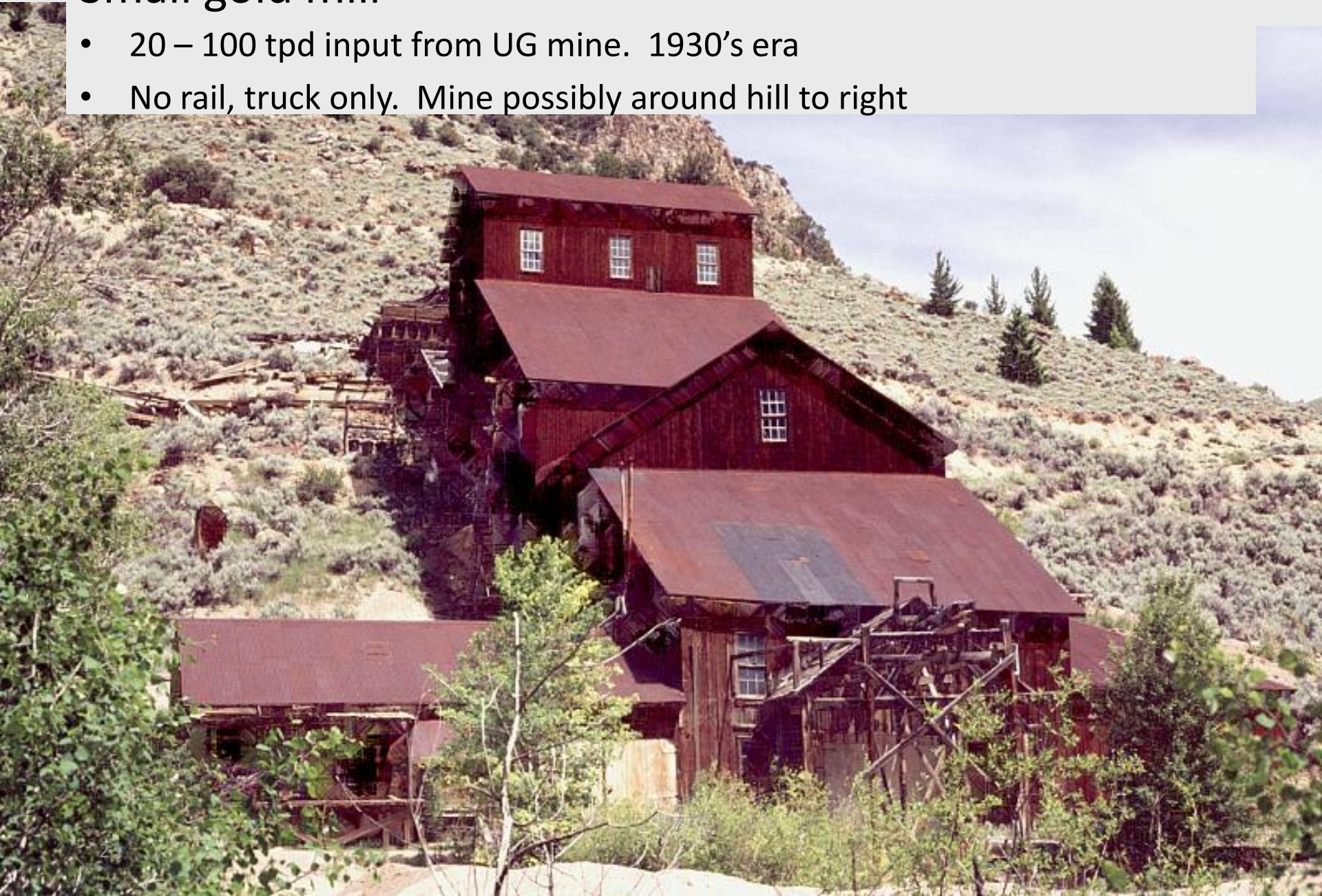
Questions to answer *before* modeling

- Commodity:
 - Gold, silver, lead, zinc, iron, copper, limestone, . . . ??
- Operation modeled
 - Mine alone, Mill alone, Mine + Mill
 - Mill alone, Smelter alone, Mill + Smelter
 - Mine + mill + smelter very uncommon other than early or small gold operations
- Scale of operations:
 - Small: 50 – 200 tpd mine output
 - Medium: 200 – 500 tpd mine output
 - Large: 500+ tpd output
- Era:
 - Historical, minimum mechanization. Pre 1870's, low output
 - Transition, introduction of mechanization. 1870's – 1910's
 - Modern, total mechanization, 1910's to present. Medium – high output



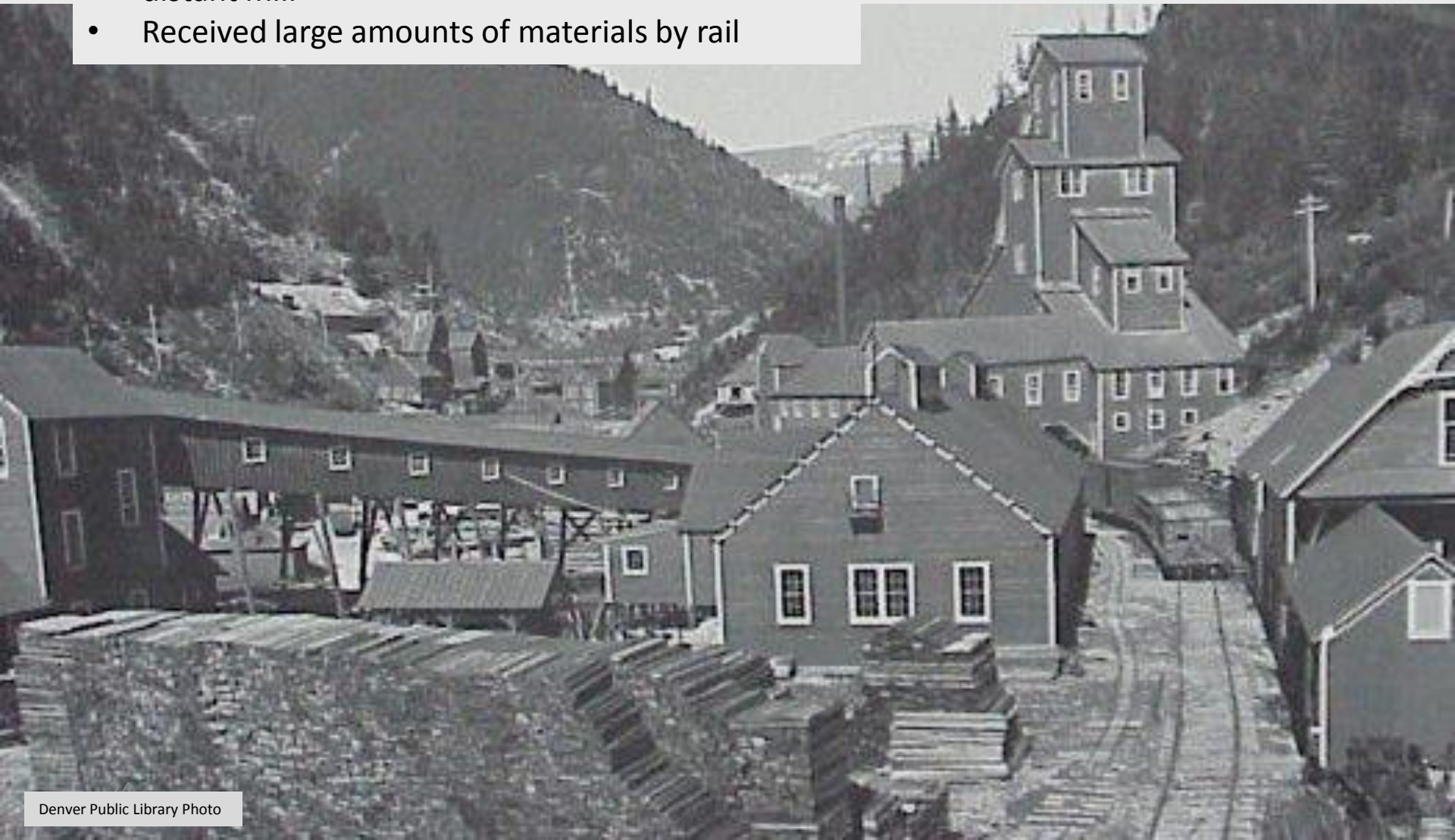
Small gold mill

- 20 – 100 tpd input from UG mine. 1930's era
- No rail, truck only. Mine possibly around hill to right



Mid sized Ag-Pb-Zn mine complex

- Early 1900's
- 200 – 500 tpd of bulk “high grade” ore by rail to distant mill
- Received large amounts of materials by rail



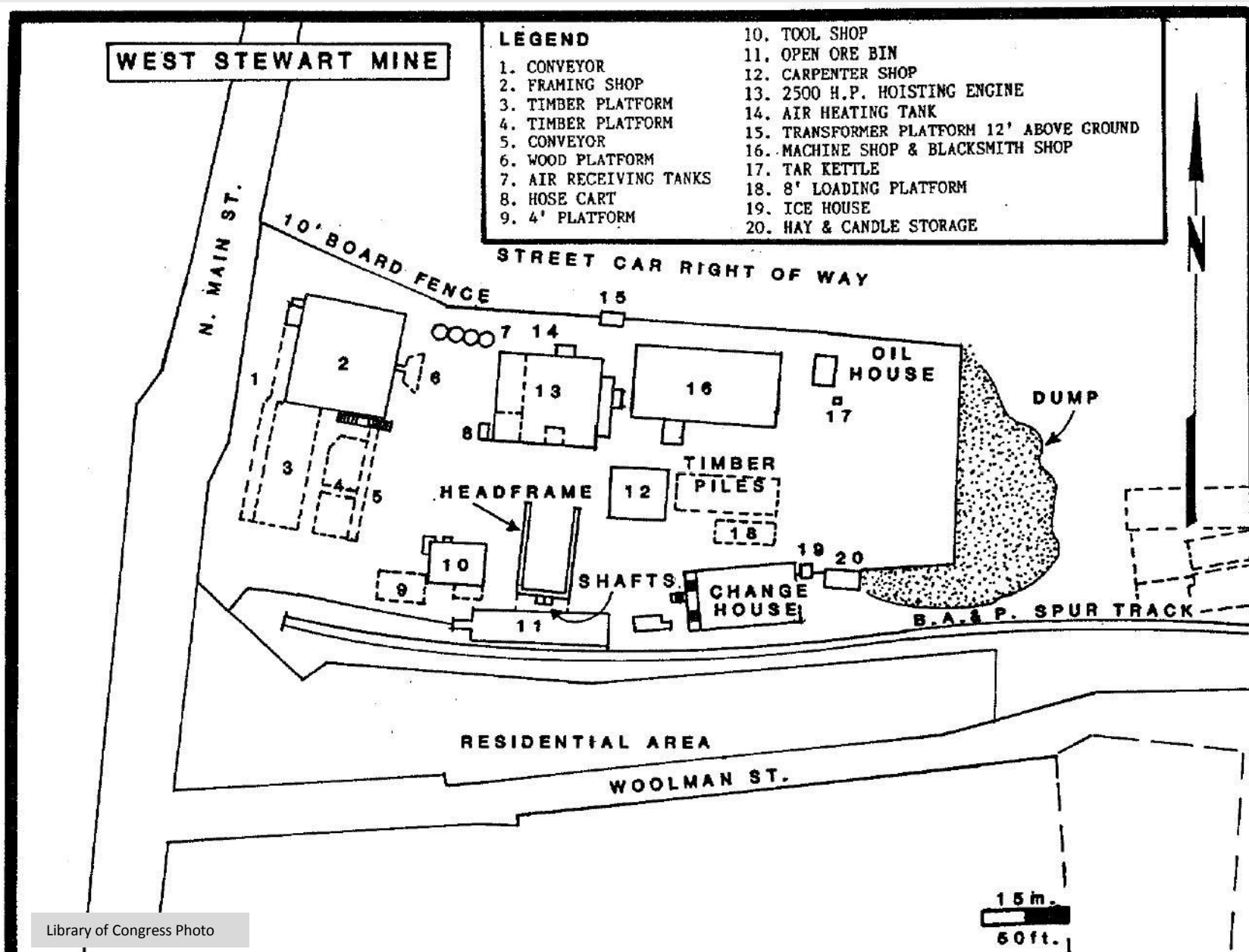
Large, deep UG copper mine

West Stewart Shaft, Butte, Mt.

- Butte mines often + 5,000 ft. deep
- Stewart Mine (r) is “two compartment” shaft
 - 2,000 – 5,000 tpd hoisting rate
- Several “4 compartment” Butte shafts
 - Used two hoists



Stewart Mine Surface Plant Layout

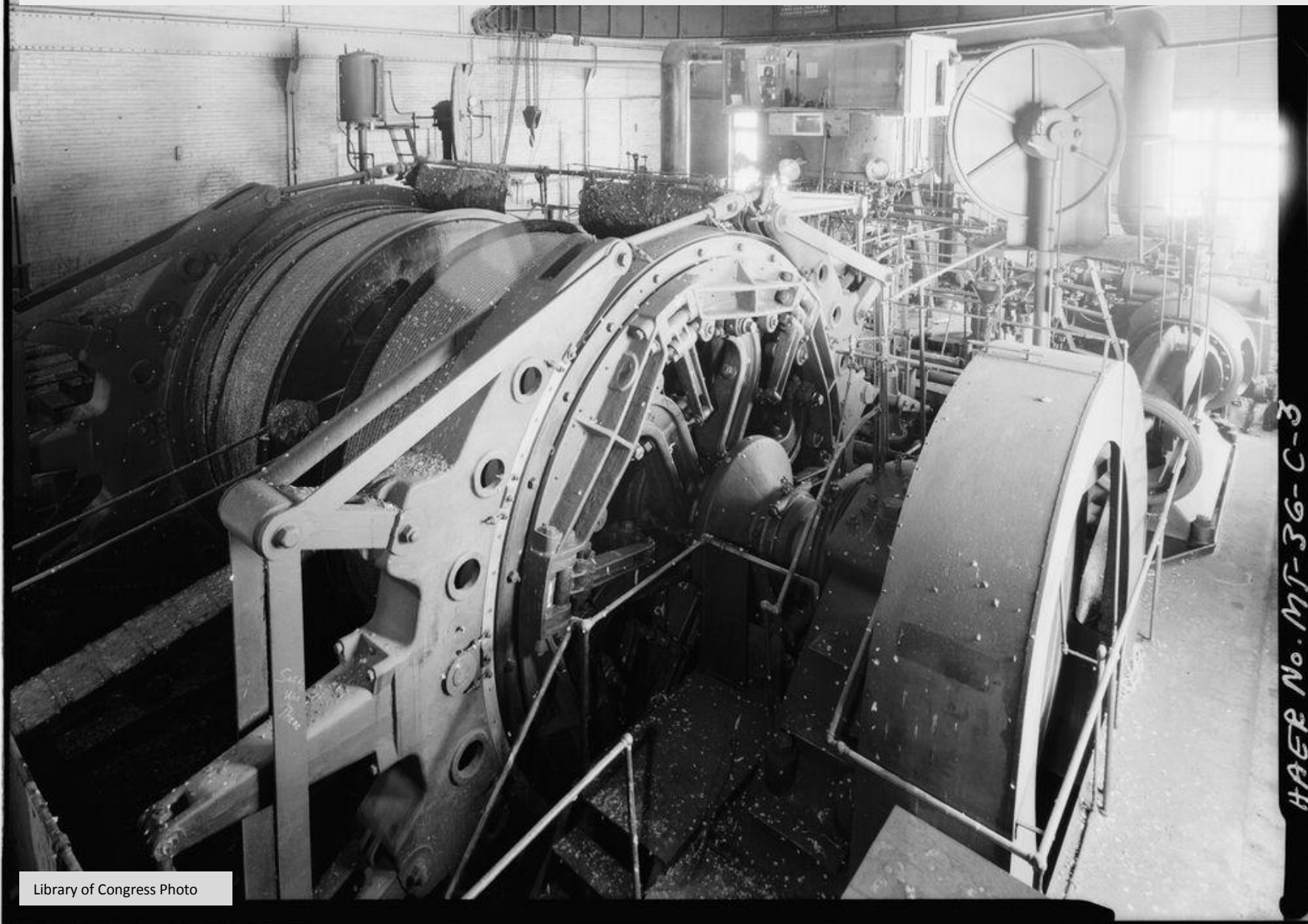


Stewart Mine Hoist House

(Bldg. 13 on previous slide. Note foot of headframe in left edge of photo.)



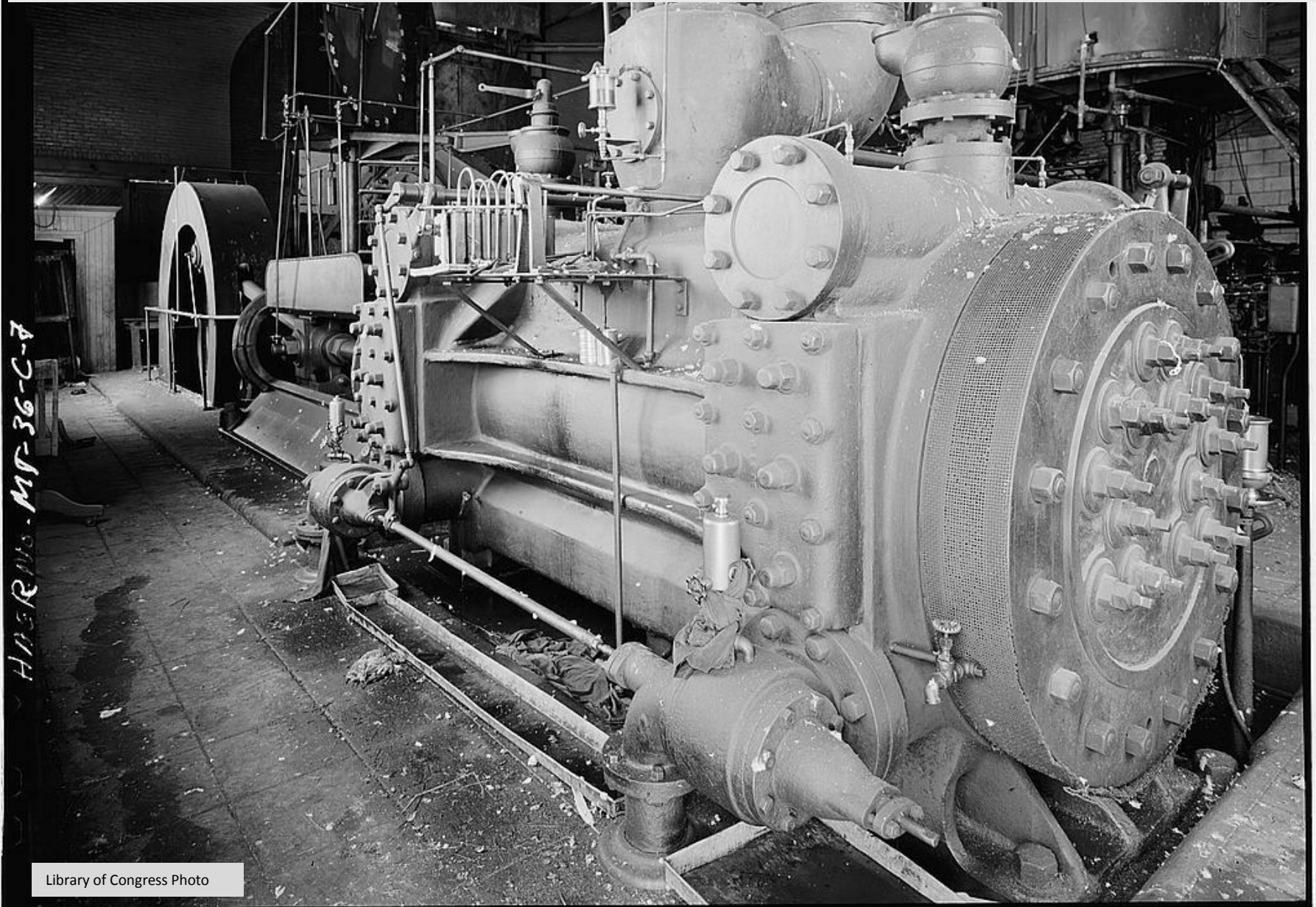
Stewart Main Hoist, Compressed Air Driven



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HAER No. NJ-36-C-3

Stewart Hoist – Compressed Air Engine



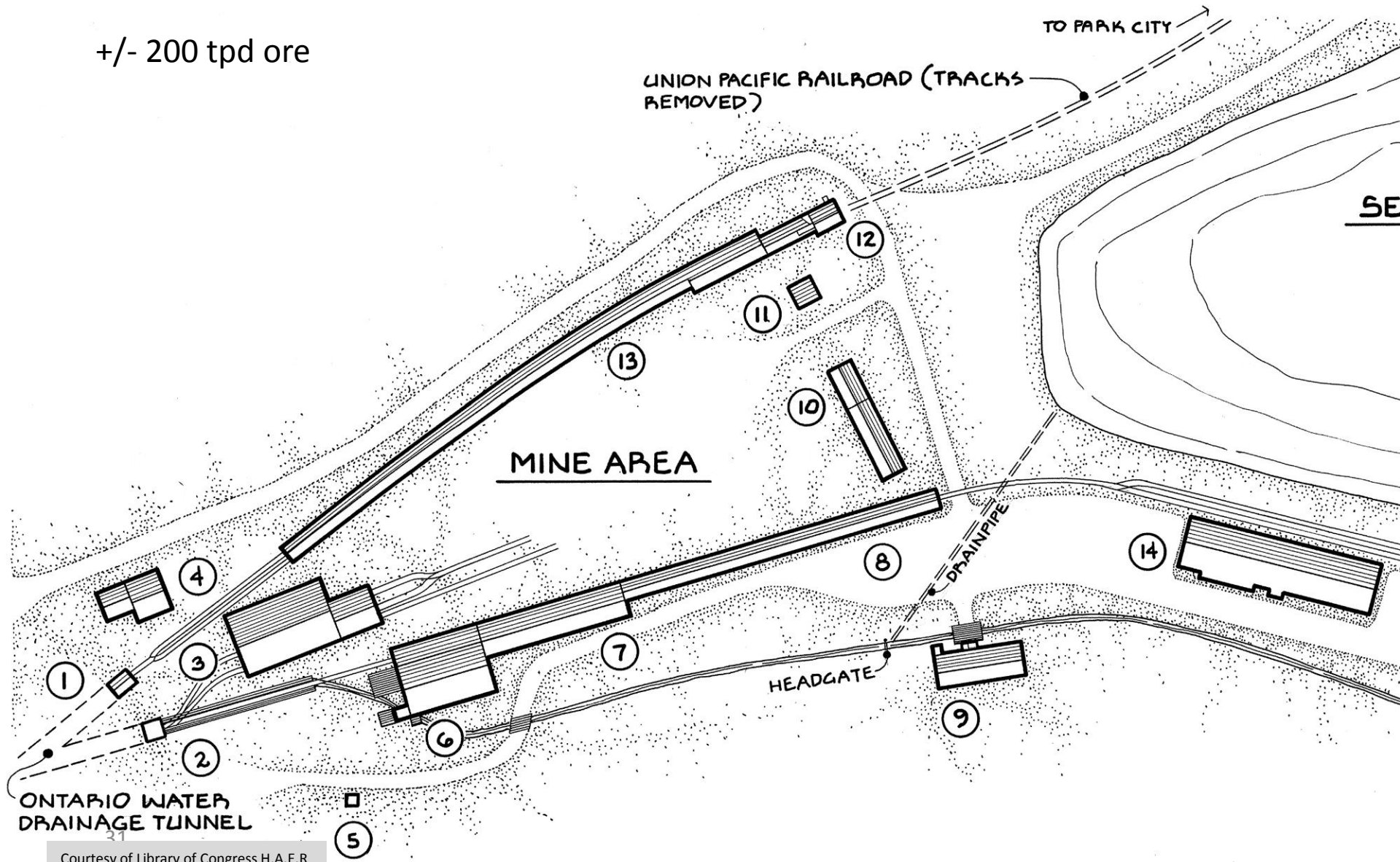
Keetley Mine, Heber City, Utah

+/- 200 tpd, UG Lead-Zinc-Silver

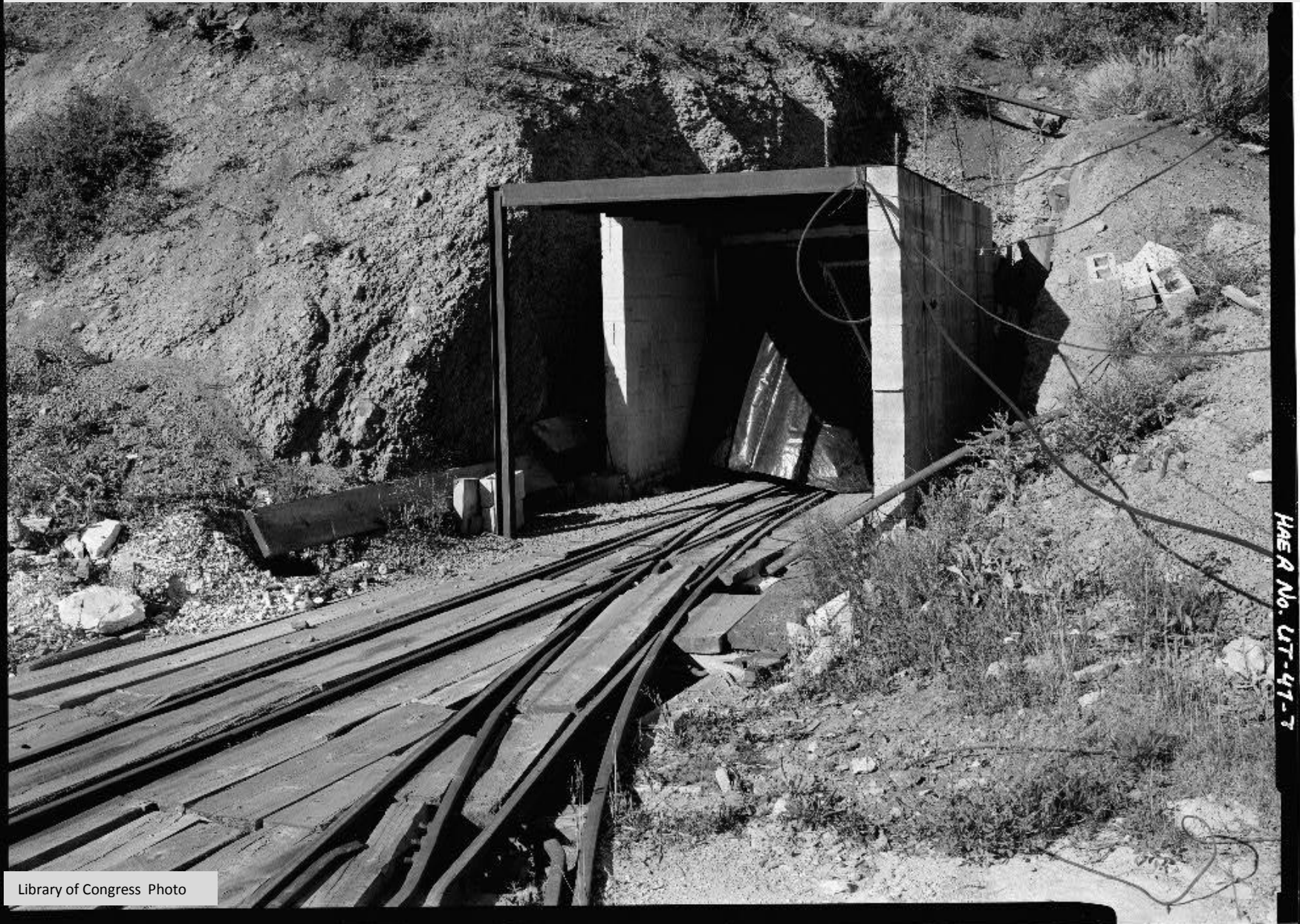


Keetley Mine, Heber City, Utah

+/- 200 tpd ore



Keetley Portal



Keetley Carpenters Shop



HAER No. UT-47-C-2

Keetley Ore Snow shed and Loadout



Rotary mine car dumper (r), ore bin conveyor (l)

HAER No. 47-47-P-3



Rotary mine car dumper. Ore bin conveyor right rear



HAER No. UT-47-D-4

Railcar loadout (rails removed)



HAER No. 47-47-D-8

Mine Logistics

- Materials into the mine and surface plant
 - Lumber for mine supports, shafts, chutes, etc.
 - Flat cars, box cars
 - Mine equipment: trammers, mine cars, rail, ties, fittings, pipe & fittings, small pumps, hose, etc.
 - Box cars, flat cars
 - Explosives
 - Special box cars
 - Fuel (coal, wood) for boilers and blacksmith shops
 - Hoppers, gondolas, flat cars
 - Large pumps, motors, hoists, air compressors
 - Box cars, flat cars, gondolas
 - General supplies
 - Drill steel, bits, small machinery, nuts, bolts, nails, screws, spikes, wire, etc.
 - Box cars



Mine Logistics

- 10" x 10" mine timbers,
- 15' rails, spikes, tools, parts
- Roof bolts, plates, pipes, powder, toilets, etc.



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Mine Logistics

- Material out from the mine
 - Waste rock
 - Ore if low value or bulk, or no onsite concentrator
 - Copper, silver, lead, zinc, iron, limestone, fluorspar, etc.
 - Gold ore (pre 1880 period)
 - Hopper cars, gondolas, flat cars (if bagged)
- Material out from the mill
 - Concentrate
 - Hopper cars, gondolas, box cars, flat cars (if bagged)
- Generally, whatever went into the mine or concentrator tended to stay on that site.
 - Other than ore or concentrate, nothing ever left.



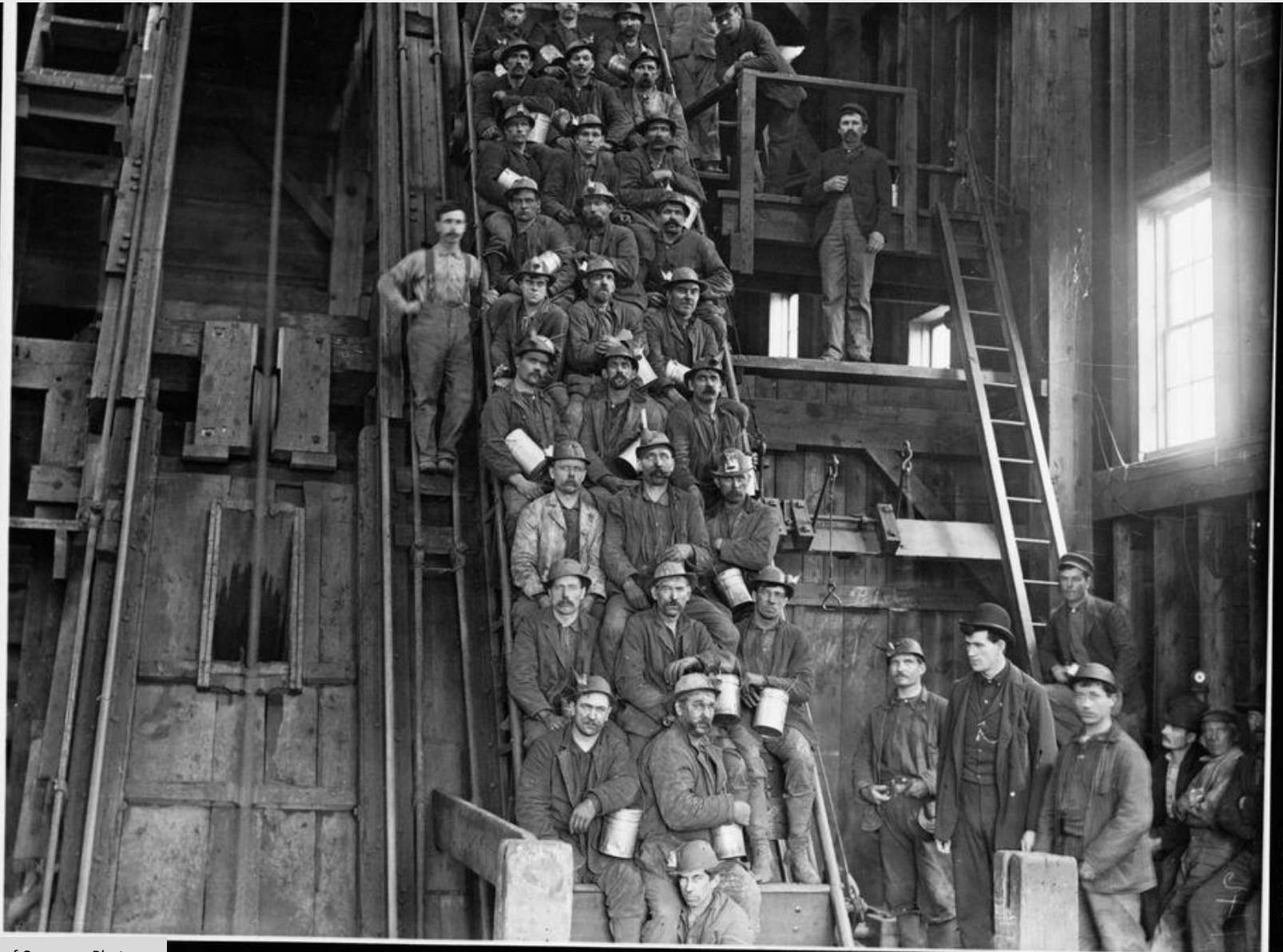
The Underground Mining Process

Mine Crew, Cripple Creek, Colorado, 1890's

1. Driller & Helper
2. Nipper
3. Face Boss
4. Timberman
5. Mucker / Trammer



Mine Crew, Quincy Mine, Michigan, 1902



HAER MI-2-114

Equipment, Utah, 1890's

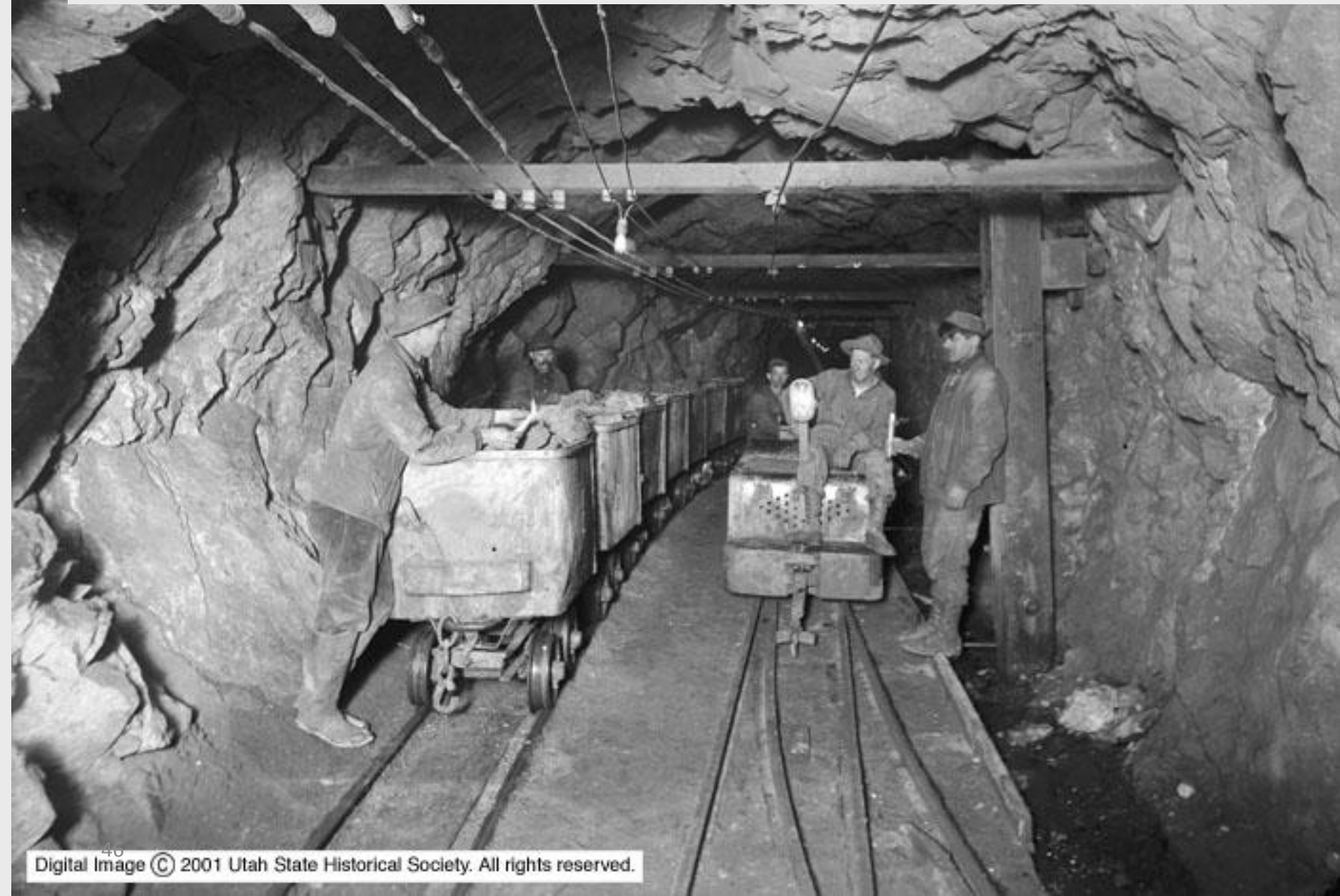
1. Single Jack Hammer
2. Double Jack Hammer
3. Drills
4. Pick
5. Shovel
6. Lighting
(Candles)
7. Hole Spoon
8. Mine Car



Pre-mechanization



Haulage Equipment, 1910 (electrified, but still uses candles)



UG “square set” construction, 1910 (note lighting devices)



Cripple Creek, 1940's – “Stoping” – Drilling ore for blasting



Library of Congress Photo



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Cripple Creek, 1940's – Drift advancement with “drill jumbo”



1940's – Loading a “face round”. (You smell *smoke*?)



After blasting, an air “slusher” mucks broken ‘stope rock’



HAR NO. MIN-50-18

Slusher Stope w/ Ore Pass to Haulage Level



HARR. NO. MAN-30-17

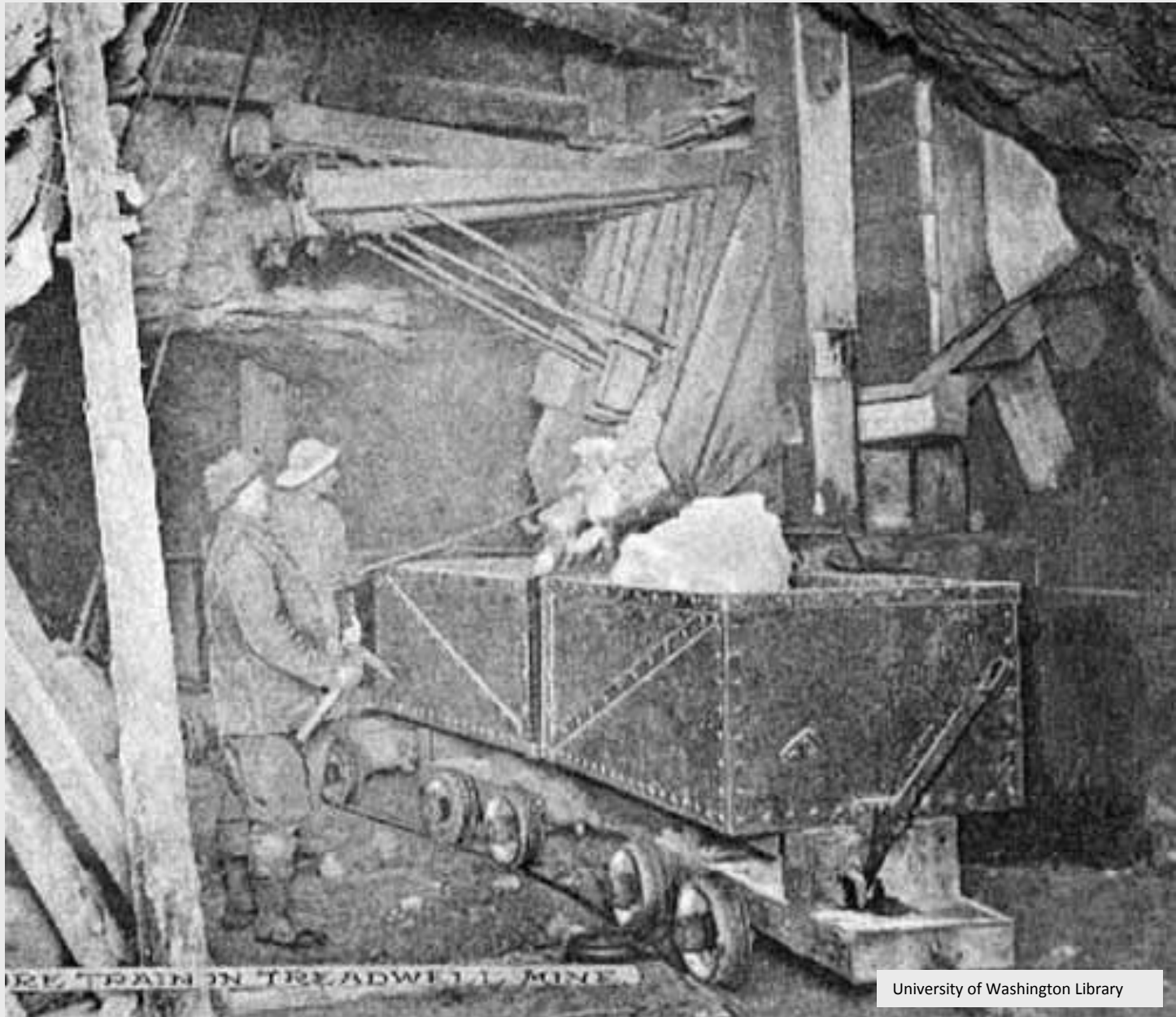
Hand Mucking face, 1890's, Victor, Colo.



Machine mucking face, 1940's. Eimco 12-B "overshot" mucker



Loading Ore Cars from Chute, 1904



Haulage "trammer", medium mine, 1940's



Haulage trammer, Jerome, Az., 1920's



Haulage, small and large mines, 1860's – 1910's

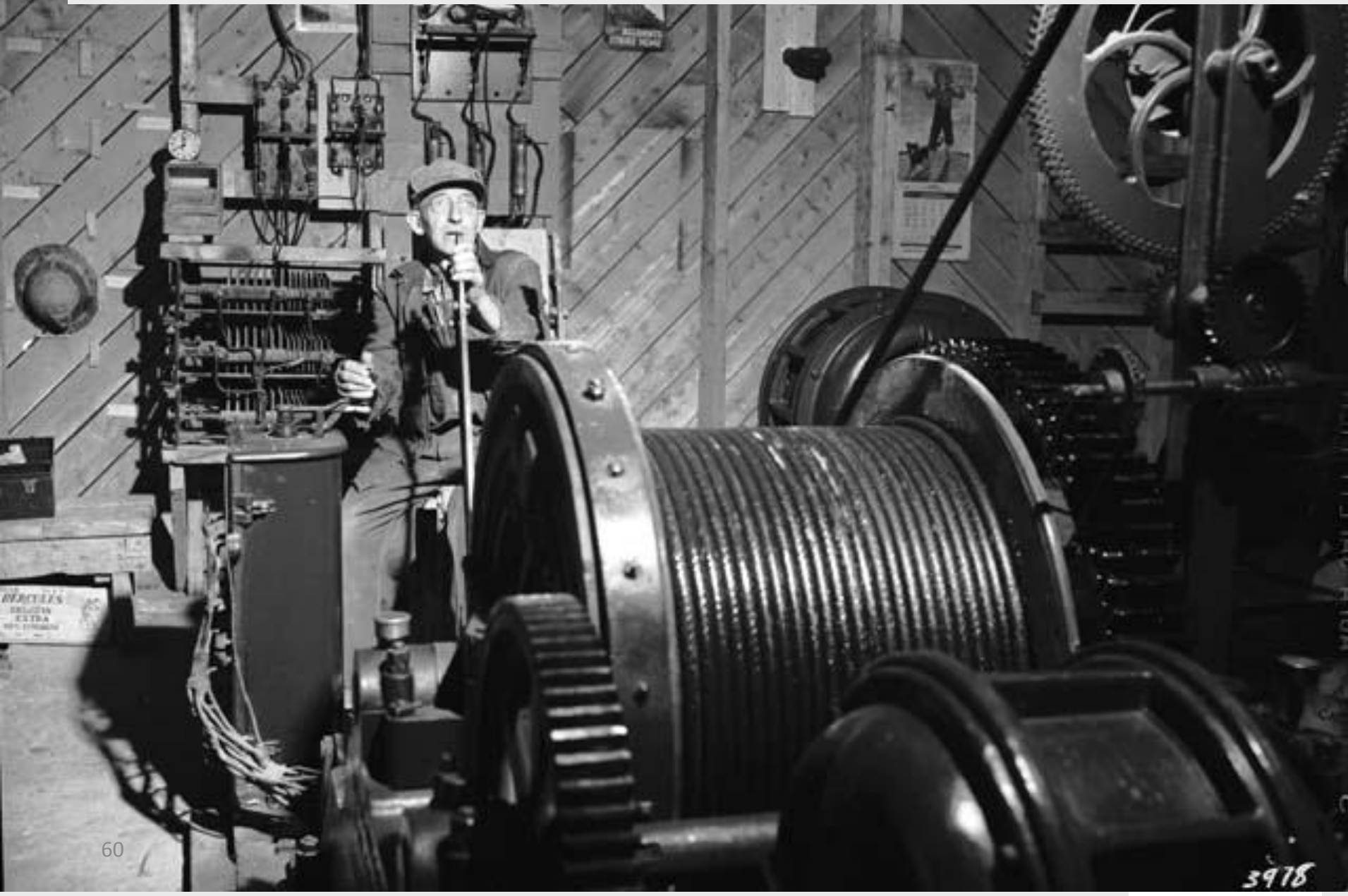


Dump pocket at shaft hoisting station

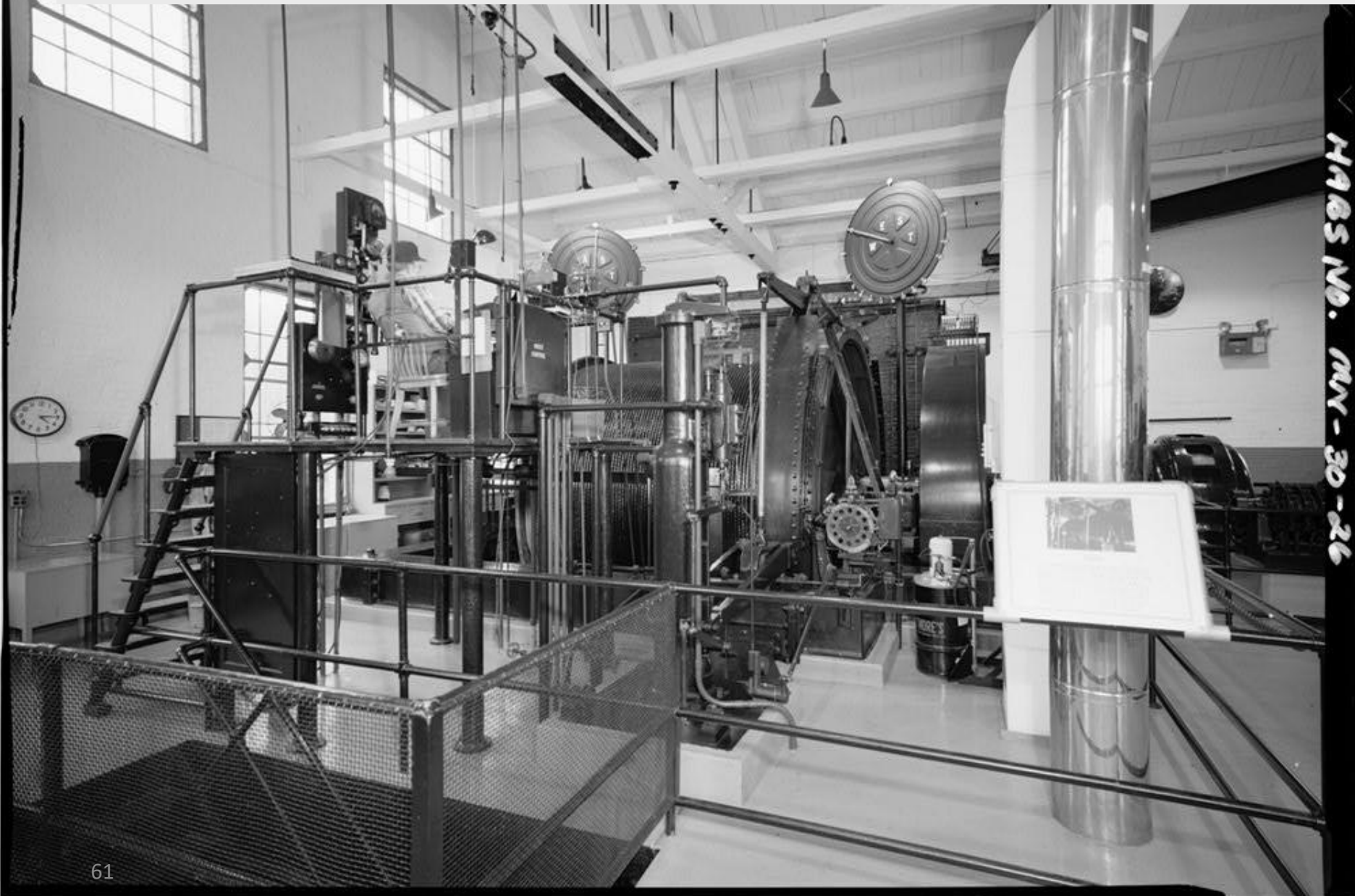


HASC NO. MN-30-23

Hoist, small mine, single drum, single skip, overshot

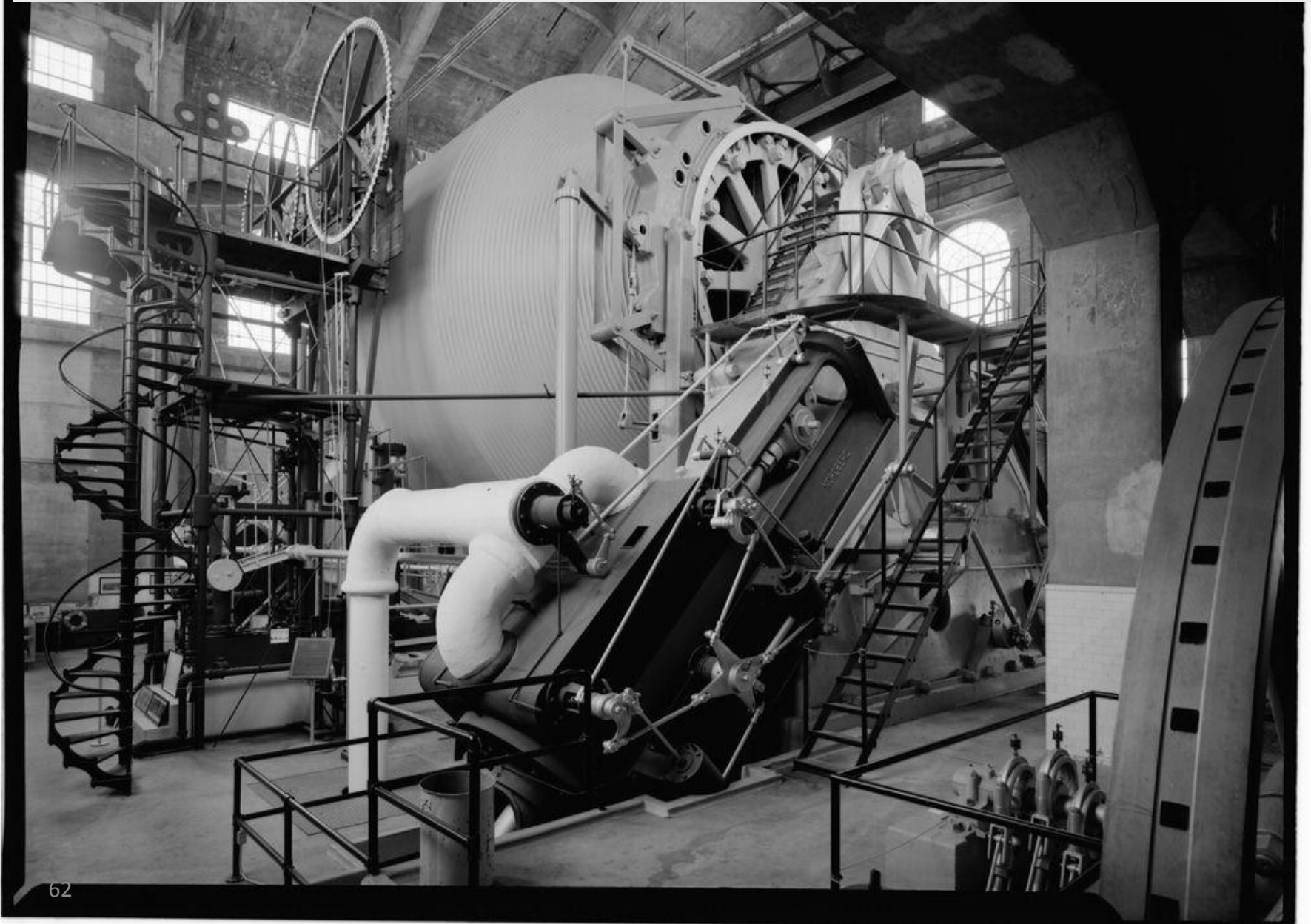


Hoist, medium mine, single drum over-under, opposed skips

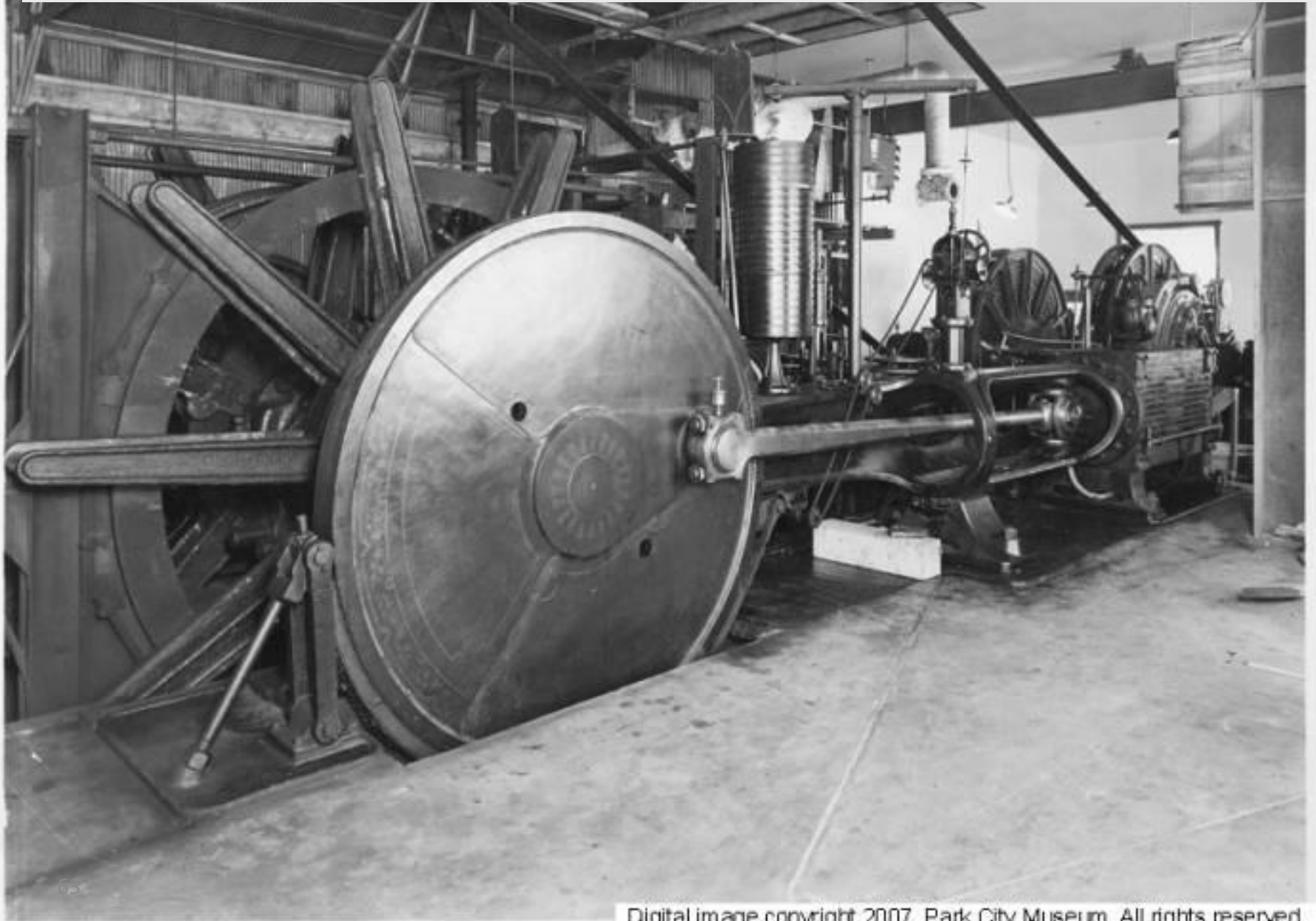


HAER M-2-59

Hoist, single drum, double taper, over-under, opposed skips



Silver King hoist, double drum, original steam drive



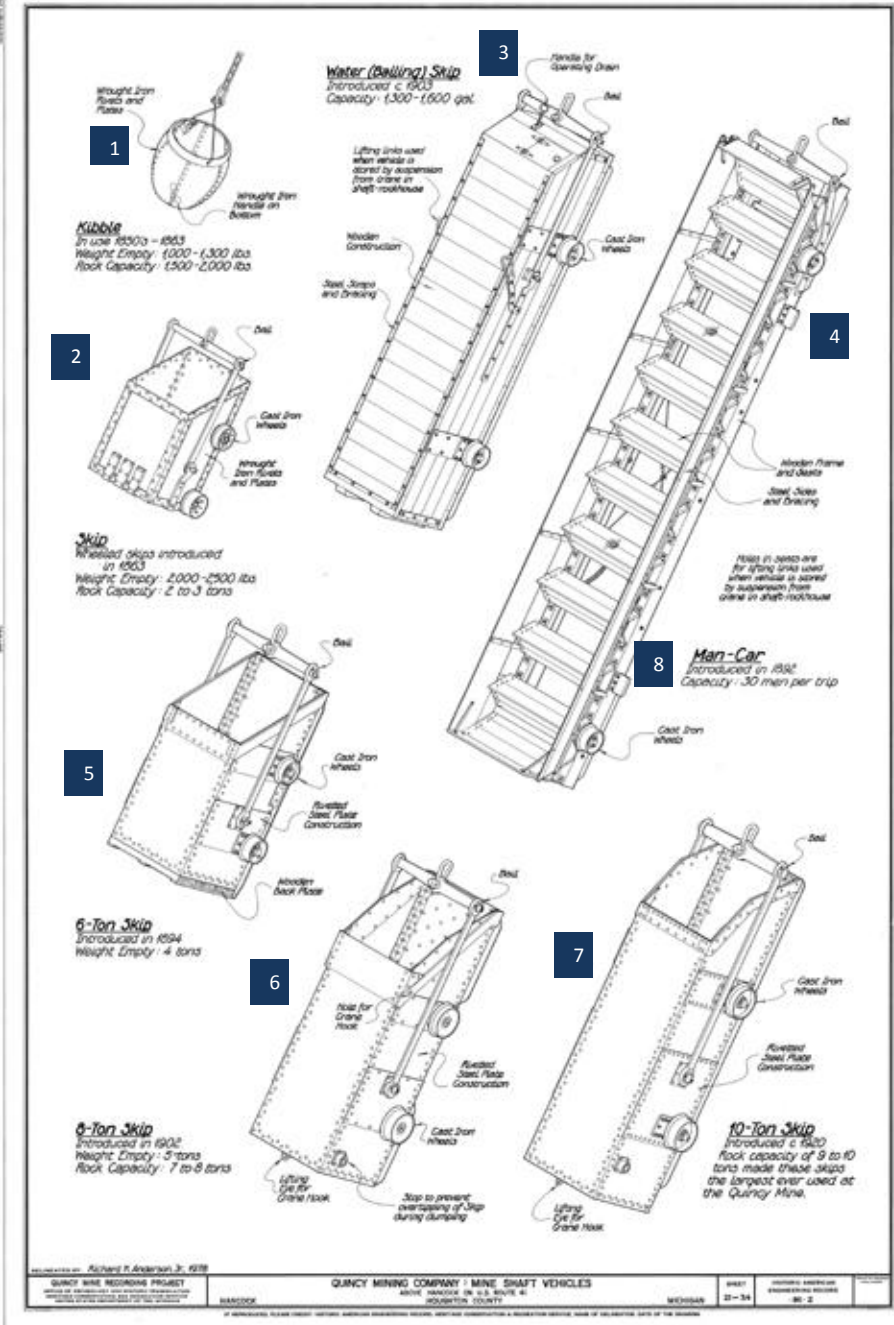
Hoisting

- Skips
 - 2 – 20 ton capacity
 - 1880's style at right
 - Still used today
 - Vertical or angle shafts
 - Most efficient when running 'opposed'
 - First comes up loaded while second goes down empty



Shaft Conveyances

1. Sinking bucket
2. 2 ton skip
3. Water skip
 - 1600 gallons
4. Man trip
 - 30 man capacity
5. 6 ton skip
6. 8 ton skip
7. 10 ton skip
- Skips above for angle shaft
 - Angle skips run on rails
 - Vertical skips run on timber “guides”



Vertical hoisting

- Old style “cage”
 - Carries single mine car
 - Loaded car rolled onto cage at shaft station
 - Hoisted to surface
 - Loaded car rolled off of cage
 - Empty car rolled on to cage
 - ‘Top Lander’ (on surface) pushed car to dump point, dumped it, brought it back to shaft
 - “Man trip” cage would be enclosed for protection



Trammers – move materials in and out of mine

- Mules used extensively



Typical Mine Car

- 1 ¼ to 1 ½ ton capacity
- 48" long x 24" wide x 24" wide
 - 16 cubic foot capacity
- Center pivot, side to side
- Center hinged for dumping
- End dump
- 18" gauge rail
- One 6' x 6' x 6' round blasted = 18 tons of muck = 12 – 15 cars per blast



Small “battery motor” trammer and end dump cars



Large “trolley motor” with side dump cars

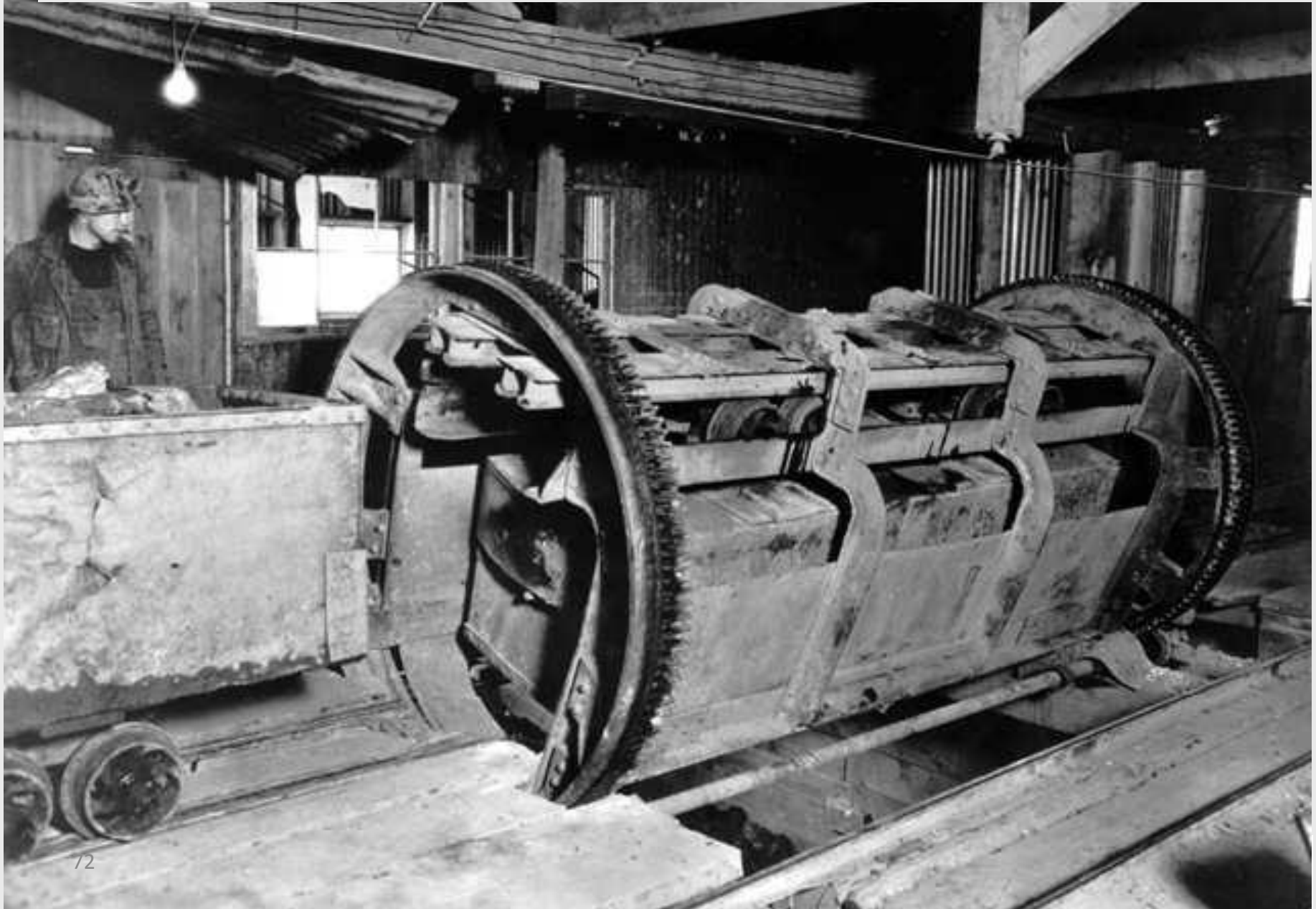


Rail haulage dumps direct into ore bin outside portal

- Bin may be at top end of aerial tramway to mill



Double car rotary dumper



Where to get mining stuff

- www.tomarindustries.com
- Campbell Scale Models
- Alpine Division Scale Models
- Guts, Gravel & Glory RR Supply
- Scale Structures Ltd.
- Walthers



- Questions?
- Discussion
- More clinics to come:
 - Mining 102: Ore Milling
 - Mining103: Smelting and Refining

